Center Independent Research & Development: GSFC IRAD

Towards a Structure and Function of Ecosystems (SAFE) Smallsat Constellation

Completed Technology Project (2016 - 2019)

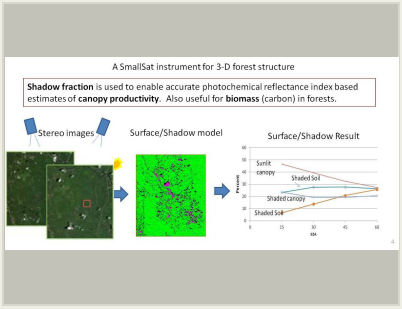
Project Introduction

This project will develop the scientific and technical underpinnings of a SmallSat constellation to make high-spatial resolution measurements of forest structure. The bulk of the effort of this project is high resolution imaging processing development, 2) optical design, and 3) Science Traceability Matrix and project concept development. Objectives 1 and 2 are needed to overcome diffraction limit issues of SmallSat-sized telescopes to get to the required resolution. This project builds upon a recent Science Innovation Fund project to inform technical requirements for a SmallSat high spatial resolution instrument to measure vegetation structure and scene shadow fraction.

Our approach utilizes the well established stereogrammetric analyses now being used in a variety of scientific applications. This requires high resolution stereo image data in order to produce the point clouds that characterize the 3D canopy structure, This information can then be used in simple models to estimate location and fraction of scene shadows. While simple in concept the practical development of a low cost, high resolution instrument is challenging. We will explore the possibility of free-form optics plus super resolution software approaches for this instrument concept. We also will develop a science traceability matrix by providing technical capabilities in light of science requirements.

Anticipated Benefits

Recent developments of estimating vegetation productivity from space using relatively low resolution systems can be enhanced by high resolution measurements of forest productivity and structure. This work focused on developing a low cost method for inferring 3D forest canopy height models.



Determining the fraction of sunlit and shaded scene compnents enablesmore accurate estimates of forest productivity and stored carbon.

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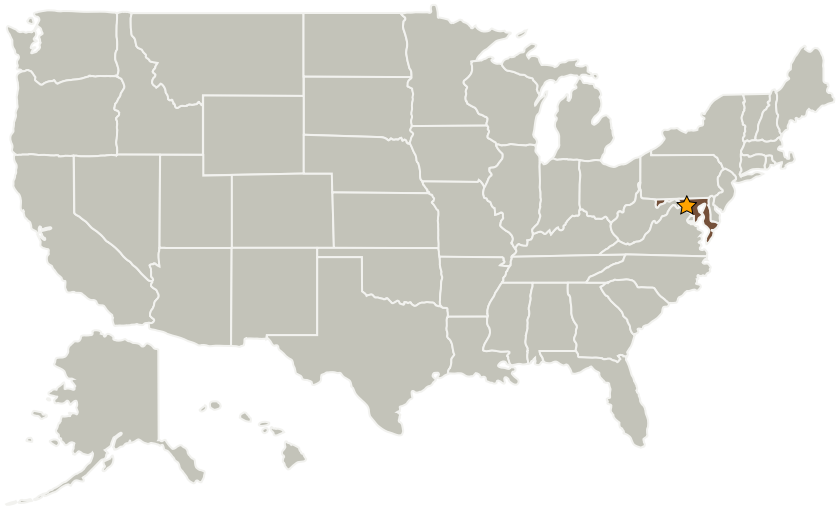
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

Project Transitions

October 2016: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Managers:

Matthew J Mcgill
William E Cutlip

Principal Investigator:

Kenneth J Ranson

Co-Investigators:

Philip Dabney
Karl F Huemmrich
Jacqueline J Le Moigne-stewart
Joel T Mccorkel
Guoqing Sun

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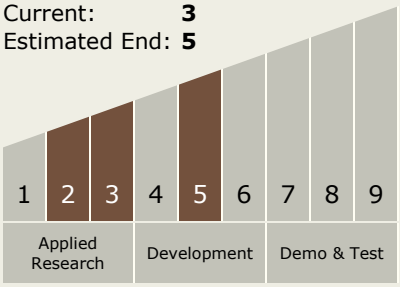
September 2019: Closed out

Closeout Summary:
One of NASA strategic goals is to Advance understanding of Earth and develop t echnologies to improve the quality of life on our home planet. Knowledge of veg etation productivity is necessary for understanding Earth's carbon balance and o ur ability grow food and fiber for human consumption. Current satellite methods for estimating forest carbon are inaccurate because of difficulties in height estim ation (e.g., scattering center - InSAR), and area (e.g, point sampling by multi -beam lidar). Forest productivity can be estimated by light use efficiency(LUE) a nd solar induced fluorescence (SIF) using multi- or hyper-spectral sensors. How ever, both of these quantities are known to be dependent on canopy shadow fra ction which is determined by sun-view-scene geometry. Improved accuracy requ ires high fidelity spatial measurements of canopy structure and shadow fraction. Affordable instruments can be built with free form optics that enable large reduc tions in mass and volume. New "super resolution" image processing techniques can overcome diffraction limit of lower cost instruments. NASA will benefit from this task by advancing understanding of vegetation productivity and the limiting factors to production. Innovative higher resolution diurnal measurements requir e new technologies such as miniaturization of optics and enhanced spatial resolu tion. beyond.
GSFC's investment in freeform optics and super-resolution structure measureme nts combine to provide lower cost high resolution measurements necessary for measuring diurnal vegetation structure and function. This complete suite of mea surement capability do not exist from space and are difficult and expensive to ro utinely provide from airborne platforms.This project examined the scientific and technical underpinnings of a SmallSat constellation to make the first diurnal high -spatial resolution measurements of plant canopy structure impacts on measure ments of vegetation function. The project combined studies of telescope design, detector configurations and computer science to develop concepts for future spa ce borne mission. We were able to leverage form a concurent IIP-IDC to bring to gether a larger team of engineers and scientists. We constructed a ScienceTrace ability Matrix to enable future mission planning. These advancements directly le d to a viable mission concept for an Earth Venture - Instrument proposal effort t hat is that is currently working toward TMR. We were also able to begin prelimin ary orbit studies with unused civil servant FTEs with agreement of the Chief Tec hnologists Office. Concept development tasks like this are improved by including outside expertise and the minimal procurement funding for this reduces the ben efits.
As mentioned this IRAD support enables our team to advance our instrument co ncept enough to justify a proposal effort to the upcoming EVI-5 call next spring.

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destinations

Foundational Knowledge, Earth

Supported Mission Type

Projected Mission (Pull)

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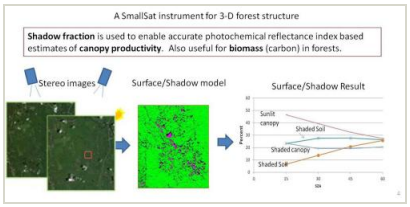
Images



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Determining the fraction of sunlit and shaded scene compnents enablesmore accurate estimates of forest productivity and stored carbon.
(https://techport.nasa.gov/image/34547)

Project Website:

http://sciences.gsfc.nasa.gov/sed/